though so obvious to an expert, often prove to be a source of infinite trouble to the beginner.

In dealing with the vexed question of crystallographic notation, we think Dr. Williams has exercised a very wise discretion. The simple and easily understood symbols of Naumann have been employed in the first instance, but in almost every case the corresponding symbol of Miller's system has been added in brackets. While all students of physics, chemistry, mineralogy, and geology ought to equip themselves with such an amount of crystallographic knowledge as may be derived from the study of this book, only a very small proportion of them are likely to be called upon to deal with the higher and more complicated problems of the science. The small minority of students who devote themselves to purely crystallographic researches may be fairly recommended to employ from the first the beautiful method of notation devised by Whewell and perfected by Miller; but it is more than doubtful if the student with a smaller amount of mathematical training would gain any real benefit from such a course. In an appendix, "on zones, projection, and the construction of crystal figures," the author of this work has indicated to such a beginner the nature of some of the methods of investigation which are pursued by more advanced students.

In any future edition of the work—and such, we feel sure, will certainly be called for—we think that the author would do wisely to add a table showing the symbols of the chief forms according to all the different systems of notation commonly employed. The student who turns to the classical memoirs of Des Cloizeaux, Mallard, Bertrand, and others of the French school of crystallography, would thus be enabled to avail himself of much valuable literature, which, owing to the employment of an unfamiliar notation, must otherwise remain a sealed book to him.

We have spoken regretfully at the outset of this notice of the general neglect of crystallographical studies; but we are compelled to admit that, for this neglect, crystallographers themselves are largely to blame. The confusion produced by numerous rival systems of notation is answerable for much of that feeling of despair among those who attempt to make themselves acquainted with the subject. If the time has not yet arrived when a uniform crystallographic language can be agreed upon, much might be accomplished if the plan adopted by the author of this work of giving in every case the symbols according to *two* systems were followed. This is already done in the *Zeitschrift für Krystallographie*, the *Neues Jahrbuch für Mineralogie*, &c., the Journals of the English and French Mineralogical Societies, and several other well-known periodicals. If a conference of the leading crystallographers of Germany, France, and England could be held to decide upon the order in which the axes should be taken in writing symbols and other similar arrangements which are purely conventional and arbitrary, we might hope to see much of the confusion removed that has so long been a bar to the progress of this most fascinating and important branch of science.

We feel assured that the simultaneous publication in this country and in America of so simple and at the same time so accurate a text-book of the subject as the work we are now considering will do much towards reviving and diffusing a taste for the study of crystallography The student who masters the contents of this little book will undoubtedly have much more to learn before he is competent to deal with all the higher problems of crystallographic science; but, however far his researches may be carried in the future—and this is, perhaps, the very highest praise we can give to the book—he will certainly have little, if anything, to *un*learn.

JOHN W. JUDD.

PHOTOGRAPHY IN COLOURS.

Photographie des Couleurs par la Méthode Interférentielle de M. Lippmann. By Alphonse Berget. (Paris: Gauthier-Villars et Fils, 1891.)

THIS interesting little *brochure* contains an account of the recent achievements in colour photography which have been made so widely known to the English public through the daily papers. Coming from the pen of an "attaché au Laboratoire des Recherches (Physique) de la Sorbonne," we may take this contribution as an authorized exposition of M. Lippmann's work, and as such it will be found useful by physicists, chemists, and photographers, as well as by the general reader who wishes to know the real state of the case concerning this important departure in photographic methods. In a short historical introduction the author calls attention to the previous photochromatic attempts by Seebeck in 1810, by Herschel in 1841, by Edmond Becquerel in 1848, by Niepce de St. Victor in 1851 to 1866, and by Poitevin in 1865. It is stated that these and all similar attempts were based upon purely chemical methods, the investigators seeking for some sensitive compound which would give chromatic impressions corresponding to the colours impinging on the film. M. Berget adds the important remark: "*a priori*, ce problème est irréalisable."

Chapters ii. to v. are devoted to elementary optical principles. Chapter ii. deals with vibratory movements and their propagation, wave-length and period, and sonorous waves. In the third chapter the phenomenon of interference is described and explained; in the fourth chapter we have sections on the luminiferous ether, the velocity of light, the decomposition of white light by a prism, and Fresnel's theory of the spectrum colours. The subject of complex colours, as distinguished from the pure colours of the spectrum, is also dealt with in this chapter, and is of special importance in connection with the colours of natural objects, to which the author devotes a short section. It is pointed out that the principle of superposition of vibrations holds good in optics as in acoustics, and that just in the same way that the diaphragm of a phonograph can take up and faithfully transmit the extremely complex system of superimposed aërial vibrations produced by the human voice, so the ether transmits the complex superimposed vibrations emanating from coloured objects. In connection with the history of the undulatory theory, the whole credit is given to Fresnel: "L'honneur de donner la première théorie rationelle de la lumière, en la considérant comme résultat d'un mouvement ondulatoire, était réservé à un savant français: Fresnel." We should like to have seen Thomas Young receive at least an honourable mention.

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The subject of interference receives more detailed treatment in chapter v., the interference of direct and reflected waves, and the theory of Newton's rings, being specially dealt with. It is not till we come to the sixth chapter that we are introduced to the main subject of the *brochure*. The principle which guided M. Lippmann in his experiments is well and tersely given. Imagine a plane metallic mirror with its reflecting surface coated with a transparent, homogeneous film of a silver haloid in albumin or collodion. Supposing a coloured ray of definite wave-length to fall on such a film, the undulations would traverse the transparent sensitive film, and being reflected from the polished surface of the mirror, and meeting the incident waves, would produce interference. The space in front of the mirror would thus be occupied by parallel planes alternately light and dark, and separated by half wave-lengths, *i.e.* by spaces of 1/4,000,000 of a millimetre. There is therefore ample space, even within the thickness of the film, for several of these planes of interference. On development, the planes corresponding to the light intervals would alone give films of metallic silver, while the dark intervals would remain unaffected. On fixing, there would thus be left in the film a series of parallel films of metallic silver separated by half wave-lengths. Any pair of such films constitute a thin plate in the Newtonian sense, and will give by interference a colour corresponding to that which produced the original deposition of the films when viewed by reflected light.

To realize the foregoing principle experimentally, M. Lippmann has found it necessary to use dry films of collodion, or albumin, or gelatine sensitized by immersion, as in the old wet collodion process: emulsions are granular and opaque, and contain particles which are gross in comparison with the half wave-length of a spectrum colour, and cannot be used. Moreover, it has not been found practicable to coat the reflecting surface of the mirror directly with the sensitive film, because the free iodine tarnishes the silver and destroys its reflecting power. This difficulty has been surmounted by making the coated glass plate one side of a shallow trough with parallel sides filled with mercury, the coated side being inwards, and in close contact with the mercury. The conditions for reflection and interference are thus fulfilled. The image of the spectrum is focussed on a glass plate with a ground surface, which is temporarily fixed to the side of the cell or trough in the same position as that occupied by the sensitive plate, *i.e.* with the ground surface inwards. After focussing, the ground glass is removed, and the sensitive plate substituted for it in the position described.

The spectrum was produced by an electric arc light of 800 candle-power, and the time of exposure for the different parts of the spectrum was regulated by interposing cells with coloured solutions, beginning with a solution of helianthin which transmits only the red and yellow, then replacing this by a cell of potassium dichromate which transmits the red, yellow, and green, and then finally exposing for a few seconds without any screen, so as to impress the blue and violet. The whole time of exposure varies, according to the sensitiveness of the film, from half an hour to two hours. The details of development and fixing are given by M. Berget, and do not differ fundamentally from the ordinary methods. The finished image, *when dry*, shows the spectrum colours by reflected light with metallic brilliancy, and as the colours are purely optical, depending only on reflection and interference, they are permanent. As the author points out, it is certainly a marvellous tribute to the fidelity of the photographic method that a series of laminæ of metallic silver separated by intervals of only about 1/4,000,000 of a millimetre should retain their positions with optical accuracy during the processes of fixing and development.

There can be no doubt—as will be admitted by all who have seen the results—that M. Lippmann is to be congratulated on having made a most important advance in the methods of photochromy. How far his experiments go towards the realization of the great problem of photographing objects in their natural colours is a question quite distinct from his present achievement. M. Berget tells us that satisfactory reproductions of coloured glasses illuminated from behind by the electric light have been obtained, but this is only a very little step in the desired direction.

" Que reste-t-il à faire pour rendre *absolument usuel* le procédé photochromique de M. Lippmann ? " There remains a great deal! Not the least of the requirements is a transparent sensitive film equally sensitive to every colour of the spectrum, and sufficiently sensitive as a whole to enable the impression to be secured with a moderate exposure, instead of 30 to 120 minutes. Till this is accomplished we are not much nearer the solution of the problem of photography in natural colours than we were before. M. Berget speaks hopefully of the prospects in this direction, and we wish every success to his anticipations. But it is no detraction from the merit of M. Lippmann's results if these have no immediate bearing on practical photographic processes. As a triumph of physical science these experiments will live.

" C'est aussi un triomphe pour la science française, car ce mode de reproduction des couleurs du spectre à l'aide des lames minces limitées par des plans d'argent constitue une matérialisation, réalisée par un savant français, de ces ondes lumineuses conçue pour le première fois par le puissant génie d'un autre Français illustre : j'ai nommé Augustin Fresnel."

With this patriotic outburst M. Berget concludes his pamphlet, and the compatriots of Niepce and Daguerre may well be gratified with this latest emanation from the physical laboratory of the Sorbonne.

R. MELDOLA.

OUR BOOK SHELF.

Geometry of Position. By R. H. Graham, Author of " Graphic and Analytic Statics." (London and New York: Macmillan and Co., 1891.)

THIS work essays to fill an existing want by providing an English text-book on the important subject of geometry of position in relation to graphical statics.

The author gives an introductory chapter on anharmonic pencils and ratios, followed by an interesting chapter on projective conics, and devotes the remainder of the book to the application of graphic methods to statical problems, including, amongst others, the discussion of Maxwell's theory of reciprocal figures.

The chapter on anharmonic pencils and ratios would have been considerably improved by the introduction, at the beginning, of more definitions and explanations of the

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